

**METHOD AND SYSTEM FOR ESTABLISHING A VIRTUAL PATH
CAPABILITY IN A FRAME RELAY NETWORK**

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BACKGROUND OF THE INVENTION

1. Technical Field:

10 The present invention relates in general to packet switching network communications and, in particular, to frame relay networks. Still more particularly, the present invention relates to methods for establishing a virtual path capability in a frame relay network.

2. Description of the Related Art:

Frame relay networks provide high speed virtual private network (VPN) capable of point-to-point high speed data transmission. Frame relay systems delimit and align frames on a channel using flags identifying the beginning and ending of a frame. Frame relay systems typically support virtual circuit multiplexing and demultiplexing through the use of a Data Link Connection Identifier (DLCI) in the frame. A DLCI identifies a virtual connection on a channel at a user to network or network to network interface. Consequently, A DLCI specifies a data link layer entity to which information is delivered or received from. A DCLI is specified in a particular field in each frame in the data link layer. The DLCI field may be either unstructured or structured.

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5 **Figure 1** shows a diagram of a particular network for illustrating concepts of prior art as well as the present invention. A source user 10 sends a message over a prior art system to a destination user at address 64.2.3.4. A router 10 which receives the traffic to this destination, references an internal routing table, determines that this address is mapped with DLCI 27.

10 Router 12 then puts the contents of the message in a frame and sets the DCLI field to DLCI 27 before sending this frame over the Frame Relay network. The frame is received by a first switching node which then consults its internal routing table to determine that the frame is to be mapped to DLCI 992. After performing the mapping, first switching node 16 relays the frame to a second switching node 18 which maps the frame to DLCI 35 and then sends the frame to router 20 which forwards the frame to the destination user at address 64.2.3.4.

25 As described above, DLCIs are pre-mapped to a particular destination. A routing table within each switching node specifies the proper output port for each DLCI frame. A unique DLCI is required to establish each of a plurality of virtual circuits which utilize a single switching node even though each of the plurality of virtual circuits connect to a single switching node over a common trunk. The DLCI field in each frame typically has only 10 bits and most of the possible bit combinations are reserved or used to convey specific user

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information. As a result there is a limited supply of unique DLCIs available. Furthermore, connectionless operations could be established within a network if the requirement is met that each frame arrives at the correct port designated by the destination identifier.

SUMMARY OF THE INVENTION

All objects, features, and advantages of the present invention will become apparent in the following detailed written description.

An the object of the present invention is to achieve a method which enables a plurality of virtual circuits which utilize a single trunk between two switching nodes of a Frame Relay network to use a single common Data Link Connection Identifier (DLCI). Another object of the invention is to achieve a protocol enabling several virtual circuits using the same trunk between two switching nodes of a frame relay network to be aggregated in a single virtual path.

A method is disclosed for establishing a Virtual Path (VP) capacity in a Frame Relay network whereby frames are transmitted over a select plurality of virtual circuits from a first switching node to a second switching node. A first switching node transmits to a second switching node a control message with a Data Link Connection Identifier (DLCI) having a predetermined value. This control message defines a virtual path aggregate in which two or more virtual circuits from among a plurality of virtual circuits are combined and identifies the individual virtual circuits which are combined to form the virtual path.

According to one aspect of the invention, the control message includes a particular field (VCID) containing one byte for identifying each virtual circuit

which is combined to form the virtual path. The control message also includes: a field for specifying a source Virtual Circuit IDentifier (SVCID) which corresponds to the input network adapter used by the virtual circuit in the first switching node; a field for a Source Port IDentifier (SPID), which corresponds to the input port used by the virtual circuit in the first switching node; a Destination Virtual Circuit IDentifier (DVCID) field corresponding to the output adapter used by the virtual circuit in the second switching node; and a Destination Port IDentifier (DPID) field corresponding to the output port used by the virtual circuit in the second switching node.

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BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

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Figure 1 depicts an illustrative embodiment of a Frame Relay network in which the methods and systems of the present invention may advantageously be utilized;

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Figure 2 depicts a block-diagram of a Frame Relay network having several virtual circuits established between a first switching node and a second switching node which are combined using the methods of the present invention to form a virtual path aggregate;

Figure 3 is a diagram for illustrating a hand shake protocol exchanged between the two switching nodes of **Figure 2** for establishing a virtual path aggregate which utilizes the methods of the invention;

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Figure 4 is the format of a control message utilized by an embodiment of the present invention, which is sent from a first switching node to a second switching node;

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Figure 5 shows a format of a data frame, utilized by an embodiment of the present invention, in which a virtual path between the two switching nodes is established; and

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Figures 6A and 6B represent, respectively, a source table and a destination table of an switching node which are updated by a control message according to the methods of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the figures and in particular with reference to **Figure 1**, there is a virtual connection established between switching node **16** and switching node **18** using a Data Link Connection Identifier (DLCI) 992. In this embodiment, several virtual circuits are established through switching node **16** and switching **18** (or between two other switching nodes of Frame Relay network **14**).
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Referring now to **Figure 2** which illustrates an embodiment of the present invention. Switching node **16** is linked to external network elements through virtual circuits **VC2**, **VC4** on a link L0 and **VC1**, **VC3** and **VC5** on another link L1. Switching node **18** is connected to virtual circuit **VC1** on link L2, virtual circuit **VC5** on link L3 and virtual circuits **VC2**, **VC3** on link L4. The inputting switching node **16** to virtual circuit **VC5** connects with another switching node **24**. External links may be network ports but may be also trunks connected to other nodes of network **14**.
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Switching node **16** connects to a backbone node switching node **26**, which connects to another backbone switching node **18**. Switching node **18** connects to switching node **28**. A virtual path **12** is established according to the methods of the invention, which is a combination of common portions of virtual circuits **VC1**, **VC2**, **VC3** that reside between switching nodes **16** and **18**.
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In this embodiment, virtual circuit **VC5** which corresponds

to a class of service different from the class of service of virtual circuits **VC1**, **VC2**, and **VC3**, is not included in virtual path **12** to illustrate the coexistence of standard virtual circuits with virtual paths according to the invention. In this embodiment, the virtual path **12**, which is implemented between two switching nodes **16** and **18** includes intermediary switching nodes **26** and **28**. However, a virtual path **12** of the present invention may be implemented between two adjacent nodes as well.

The assignment of virtual circuits to a new virtual path is configured within both switching nodes **16** and **18**, while the intermediary switching nodes remain transparent. An embodiment of a protocol is defined, in accordance with the methods of the present invention, to support the data exchange and the negotiation between the two nodes for configuring the nodes to comprehend the new virtual path aggregate. This embodiment is illustrated in **Figure 3**.

A control message is sent from switching node **16** to switching node **18** to request the configuration of a new virtual path. To indicate the purpose of this message, the DLCI field is set to predefined value 999, which is one of the values which are reserved for layer management of the frame bearer service. Node **18**, receives this control message, determines from the DLCI value of 999 that the purpose of the message is to establish a virtual path, and then records the chain of VCs assigned to this new virtual path aggregate identified by the DLCIn.

Node **18** answers the request from node **16** by sending a control message either acknowledging affirmatively or rejecting the request to establish a virtual path. Affirmative acknowledgment is sent if the virtual circuits are operational and the quality of service requested in the line with the authorized parameters. A rejection is sent if the VCs are not operational in an aggregation mode. In the preferred embodiment, status information is included in the rejection message for identifying the reason for the rejection, which is forwarded to the network management system for filing and analysis. If no answer from node **18** is received by node **16** then node **18** may not have understand the request. A timer is used within node **16** to detect this error, which may also be forwarded to the network management system for filing and analysis.

If a rejection message or no answer is received by switching node **16**, then the virtual path is not formed and error information is forwarded to the network management system for filing and analysis.

If an acknowledge message is received by node **16** from node **18** and no other condition occurred which prevents forming the virtual, then node **16** responds by sending node **18** a message affirming the virtual path aggregate. Otherwise, depending on the message received by node **16**, a message is sent by node **16** to node **18** either indicating the error or acknowledging the rejection from node **18**. Node **18** may also use a timer to detect the absence of a response from node **16** and then

generate an error condition communicating the absence of a response to system management.

Figure 4 illustrates an embodiment, which is in accordance with the present invention, of a format for a control message sent from a first switching node to second switching node to initiate the configuration of a virtual path. This control message has a defined data structure and uses a specific value for DLCI (in this case DLCI set to 999) which is predefined, through network or inter-node protocol, to indicate a negotiation for configuring a virtual path between the two nodes. A specific DLCI may be assigned for each logical connection between two nodes of the network where a virtual path aggregate is needed. In the disclosed embodiment, each field of the control message, shown in **Figure 4**, is defined as follows in table 1.

Table 1

FIELD NAME	BITS WITHIN FIELD	FIELD DEFINITION
VPID		The Trunk Virtual Path Identifier
AGGT		Aggregation type 14 bits (0-13)
	0,1	Defines nb of bytes used for merging VC filed in data frame (1, 2 or 3 bytes) corresponds to the size of the VCID2,3 : number of bytes for Source Port definition (6,14, 22 or 30 bits)
	4,5	Number of bytes for Destination Port definition (6,14, 22 or 30 bits)
	6,7	Defines the size of the QoS Field : 0, 1, 2 or 3 bytes (Flow ID + QoS)
	8 to 12	Indicates whether the message is a single command or multiple commands and if multiple, then the number of VCs included
	13	Spare bit
VCID		Trunk VC identifier

This control message, may be used to set up one virtual path aggregate and one or more VCs, which have portions that are combined to form a new virtual path. Preferably, whenever one or more new VCs are established between the two nodes, a control message is sent to include the new VC(s) in the virtual path. For this reason, a control message need never contain many VC identifications.

In each control message, of the disclosed embodiment, the field after DLCI 999 of 10 bits contains the Virtual Path IDentifier (VPID) which identifies the common DLCI N for transmitting the frames belonging to all aggregated VCs between the two nodes.

The AGGT field of 14 bits specifies the aggregation type and mode corresponding to the aggregated VCs listed after this field. The AGGT filed allows alignment of the boundary of the VCs definition to an exact number of bytes.

The Virtual Circuit IDentification, specified in the VCID field, contains as many bytes as there are VCs to be combined. For each VC, the fields, which follow the VCID field, define the Source Virtual Circuit IDentifier (corresponding to the input adapter of switching node **16**), the Source Port IDentifier (corresponding to the input port switching node **16**), the Destination Virtual Circuit IDentifier (corresponding to the output adapter of switching node **18**), the Destination

Port Identifier (corresponding to the output port of switching node **18**) and the QoS field which defines Priority, Queue, Traffic type, Flow ID (per VC).

5 **Figure 5** shows an embodiment of a structure for a data frame according to the methods of the present invention. The header is the VP identification which fits into the DLCI field. The VC identification of the VC number i , that is $\text{VCID}(i)$ is put the first byte of the data field which is ended by the Frame Check Sequence (FCS) field. The control message, sent to request configuration of a virtual path, as shown in reference to
10 **Figure 4**, informs the receiving switching node which port and on which VC this data frame is to be mapped.

15 Each time a control message is sent between the two switching nodes, each node updates its internal identification table, such as those shown in **Figures 6A** and **6B**. For the sending node, the source table maps, for each coupled VP/VC respectively identified by VPID and
20 VCID, to the Source VC identifier and the Source Port Identifier. Similarly, for the receiving node, the destination table maps for each coupled VP/VC, to the Destination VC identifier and Destination Port
25 identifier.

30 Each time a frame is received on an input adapter in switching node **16**, the node's internal source table is consulted to determine whether this frame is to be encapsulated into a VP structure of the present invention or transmitted as a normal VC frame. Similarly, the receive adapter of switching node **18**, consults an

internal table to determine whether this frame is a normal VC frame which will be mapped using the classical forwarding mechanism or is a VP encapsulated frame of the present invention which will be forwarded to the port specified by the defined VC given by the line pointed by this frame's VP/VC identifier.

Note that any virtual circuit which is no longer used should be deleted from a virtual path. For this purpose a supplementary field in the control message, such as the VCID field, is reserved in the disclosed embodiment. Alternatively, the first switching node may utilize a time counter for detecting extended periods of non-activity by each VC which triggers the first switching node to remove the inactive VC from the VP. In this case, The source table is overwritten in the first switching node. An internode protocol message from the first switching node to the second switching node is sent to remove the inactive VC from the destination table.

The preferred embodiment enables some VCs or the entire VP to be canceled by a particular predefined control message in which bit 13 of the AGGT field (See table 1) is set to 1. In this case, if all the VCID fields following the AGGT field have all their bits set to 0, this indicates that the entire VP is to be removed. Only some VCID fields may have all their bits set to 0 to indicate that only these VCs are to be removed from the VP. This method provides for an efficient re-configuration.

5 While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.

6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100